Forest Regeneration on the Western Hutt Hills, Wellington

BARBARA H. CROKER,

Botany Department, Victoria University College

[*Read before Wellington Branch, May 14, 1952, received by Editor, May 31, 1952.*]

Abstract

THE course of regeneration of native lowland forest has been traced on an area of the Western Hutt hills by analysing the different communities that appear to be part of the succession. The environmental and edaphic factors were studied as far as possible and estimations of the ages of the existing plants in the different communities were made to gain some idea of the time needed for regeneration. Four distinct seral communities occurred in the course of forest regeneration in this area. These communities were dominated by *Pteridium*, *Coprosma*, *Melicytus* and *Cyathea*. Evidence that each was part of the succession was the fact that seedlings of succeeding communities developed beneath the canopy of preceding stages. The final *Beilschmiedia tawa* dominated association is believed to be the climax forest in this area.

INTRODUCTION

FOREST dominated by podocarp species was regarded by many of the early settlers as an indication of land suitable for pasture. In many places pasture was established successfully by felling and burning the forest, and then sowing with introduced species of grasses, but on the steeper, damper hills the introduced grasses often failed to become established, and gave way to growth of native plants. This replacement of pasture species by indigenous species has been commonly referred to as second growth; from the agricultural point of view this is regarded as a degeneration of pasture (Levy, 1923), whereas from a purely ecoloical point of view it is equally a regeneration of native vegetation.

Because of its economic aspects and the importance to farmers of maintaining pasture growth, literature on this subject has dealt mainly with the degeneration of pasture land and methods for its prevention. Little has been published on regeneration of lowland forest in New Zealand, and there are conflicting opinions as to the relationships of the communities dominated by podocarp and by broadleaf species. However, broadleaf forest dominated by *Beilschmiedia tawa* was regarded by Cockayne (1927) as the probable climax subtropical rainforest in the North Island south of latitude 38° S.

The Wellington fault scarp forms the western boundary of the Wellington Harbour and the Hutt Valley (Cotton, 1949). The fault scarp has been deeply dissected by numerous streams that flow into the Hutt River and the harbour, and thus steep gullies more or less at right angles to the relatively precipitous front of the scarp have been formed.

Part of this fault scarp forms the Western Hutt hills, and in 1949 a detailed study was made of the vegetation on a small area of these hills, a mile north of Belmont. The area chosen had been in the hands of the present owner for nearly 40 years, and the history over this period was fairly accurately known. The property had been protected from fire as much as possible, and several stages of regeneration of forest from second growth could be distinguished. From an analysis of the components of the different communities and an estimation of the ages of the existing plants it was possible to gain some idea of the course of regeneration of lowland forest on these hills.

Historical Background

When the early settlers arrived a little over a hundred years ago the dominant trees of the original forest which clothed the Hutt Valley practically to the Petone foreshore were mainly *Podocarpus totara, P. dacrydioides* and *Dacrydium cupressinum,* (totara, white pine and rimu), some *Metrosideros robusta* (rata) and in swampy areas *Laurelia novae-zelandiae* (pukatea). By 1870 nearly all the timber had been cleared from the valley, and when the railway was put through to Lower Hutt, in 1874, and extended to Silverstream in 1875, totaras were cut from the adjacent hills. About this time much of the totara forest on the Western Hutt hills was milled and the debris burnt, so that the land could be sown with pasture grasses.

On the area studied the remains of a logging tramway were found in 1912, but no definite information on the date of milling could be ascertained. There are, however, two possible dates, these are approximately 1870 and 1890. By 1851 the road along the foot of the Western Hutt hills reached Belmont, and there was a regular ford across the river to the farms on the eastern side. The area beyond the end of the road was gradually opened up, and soon the road was continued over the hills from Belmont to Pahautanui. After the flood of 1858 had swept away nearly all the flat land on the west side of the river, including 90 acres of a farm near Belmont, there was very little land for farming except on the hills, therefore the settlement in the late 1860's at Pitcaithly's Siding (about a mile and a half north of Belmont) may have been a sawmilling community or the start of farming on these hills From these facts the most likely date for the milling of the original forest in this area is about 1870.

After the milling much of the Western Hutt hills was intensively grazed, but the steeper, damper slopes apparently soon reverted to second growth of native shrubs and are still shrub covered. The less precipitous slopes are still grazed, but there is a continual tendency to revert to second growth. The composition of this second growth varies according to its exposure to sun and wind. In the gullies and on the damper slopes are mixed shrub communities in which the tree ferns *Cyathea* and *Dicksonia* and the small trees *Coprosma* and *Melicytus* (mahoe) predominate, while *Pteridium* (bracken) is common on recently burnt areas. These are replaced by *Leptospermum* (manuka) and *Cassinia* (tauhinu) scrub on the drier slopes and exposed ridges.

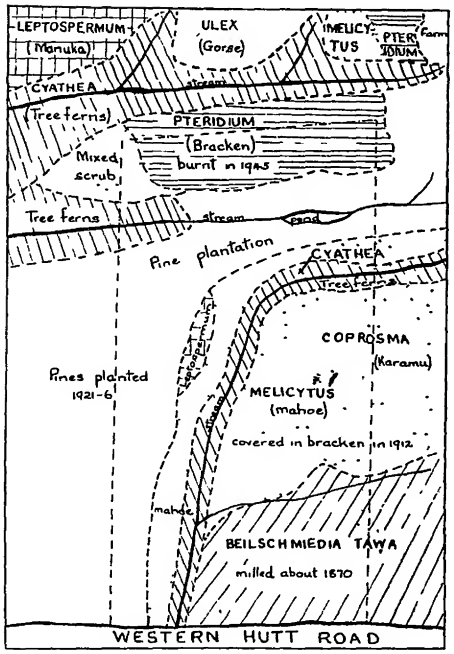

FIG. 2.—Sketch map of the area to indicate the distribution of the communities.

The main south slope in the area studied (Fig. 1) supports three communities which appear to be different stages of one succession. The forest community is thought to date from the original milling and was dominated in 1912, as it is now, by *Beilschmiedia tawa*. The rest of this slope was then covered in bracken. About six years later *Hebe salicifolia* and *Coprosma robusta* were prominent above the bracken, and now there is a tall scrub community dominated by *Coprosma* or *Melicytus* which form a canopy at 15 to 18 feet. In 1916 there was a small fire which was confined to a very narrow belt up this slope, which is now marked by a canopy of tree ferns. Between 1921 and 1926 the main ridges were planted in *Pinus radiata, P. muricata* and *Pseudotsuga taxifolia*. The last fire occurred in 1945 on a western ridge, and this ridge is now covered in bracken. The distribution of the present vegetation and the dates of the fires are shown in the sketch map (Fig. 2).

CLIMATE

Frequent readings of rainfall, temperature and humidity were taken and compared with readings at the Meteorological Office, Wellington, which is situated 12 miles south and is of similar altitude and aspect. The rainfall averages 47 to 50 inches per annum; there are no extremes of temperature and frosts are not severe. The topography of the area is such, however, that each slope has its own microclimate. On the south facing slopes the soil is damp, the humidity is relatively high and shows little fluctuation; the temperature also tends to be uniform. These slopes receive rain from the south, and are sheltered both from the prevailing north-west wind and the direct sun. Most of the north facing slopes are dry and warm, as they are exposed to direct sun all the year. The soil is dry even in winter, temperatures are usually higher than the average air temperatures, and the relative humidity tends to be low. Isolated readings indicate that in summer evaporation may be significant as it is approximately ten times as great as on the opposite south facing slopes. These north slopes are often exposed to the prevailing north-west winds. Greater fluctuations of temperature and humidity occur on the ridges, and on some the vegetation is noticeably windswept.

SOIL

The parent rock in these hills is greywacke, which is very cracked as a result of faulting. Weathering of the greywacke has formed a silt loam with a high percentage of clay, in which small rock fragments are abundant On the flatter

areas the soil profile shows little differentiation; there is a varying amount of humus, dependent on the vegetation, and an increasing content of fine rock particles till the parent rock is reached at a depth of three to four feet. At two and a-half to three feet there is a greater concentration of clay and occasionally in this region a few red streaks indicate some slight deposition of iron salts. A greater depth of humus has accumulated under the tawa, otherwise the soil profile is very similar to that under the bracken. On the steeper slopes, however, there is only a skeletal profile in which large rock fragments are abundant, little soil accumulates, and small surface slips are frequent. On these slopes the roots of the trees are often seen growing out over the surface of the rock.

Description of the Area

An area of about twenty-five acres was studied in detail. Each distinct community was studied by chart and list quadrats and transects, soil analysis and measurements of the climatic and light factors. The results of these analyses which are included in an unpublished thesis (Croker, 1949) indicated that there were several recognisably distinct communities that could be regarded as seral communities in the regeneration of forest from second growth on pasture. A brief description is given of each type of community. A diagrammatic cross section of the area (Fig. 3) shows the relative positions of the different communities. The size of the vegetation has been exaggerated to give some idea of the relationships of vegetation to topography.

Farmland

In 1949 the flatter areas of the present pastures on these hills were being over-grazed by cattle, sheep and rabbits. *Hypochaeris radicata* (cat's ear) was becoming the dominant plant. The hills were still predominantly grass covered, but some of the slopes had reverted to indigenous scrub. On the damper slopes the scrub was dominated by *Coprosma robusta* and *Melicytus ramiflorus*, with *Cyathea dealbata* and *C. medullaris* dominant in the gullies, while *Leptospermum scoparium* and *Cassinia leptophylla* were dominant on the drier slopes (Fig. 4).

Pteridium Community

One of the common forms of second growth on recently burnt areas, and one of the earliest stages in regeneration was a community dominated by *Pteridium aquilinum* var. *esculentum* (bracken). A north-south ridge fairly exposed to the prevailing wind was last burnt in 1945, and four years later, in 1949, *Pteridium* formed an almost continuous canopy at three feet. Below the canopy were young *Geniostoma ligustrifolium* (hangehange), *Coprosma robusta* (karamu), *Melicytus ramiflorus* (mahoe) and a few *Hebe salicifolia*. *Geniostoma* seems to be the first native shrub species to establish under the bracken canopy. The introduced species *Hypericum androsaemum* (tutsan) and *Leycesteria formosa* (Himalayan honeysuckle) were also well established, and in places were level with the bracken canopy. There was a dense ground cover consisting mainly of introduced weeds and grasses, including *Holcus lanatus, Agrostis tenuis, Hypochaeris radicata, Plantago lanceolata, Taraxacum officinale, Trifolium repens* and *T. dubium*. There were also mats of the native *Hydrocotyle moschata*, and a large number of seedlings of *Geniostoma, Coprosma, Melicytus* and *Brachyglottis*.

When examined again in 1952 this community was beginning to show marked changes. Instead of a continuous bracken canopy at three feet the bracken is now five to six feet tall and the canopy is very broken. *Leycesteria* six feet tall stands above the bracken, but in several places it is dying out. Everywhere through the bracken, below and level with the canopy are vigorous young shrubs of *Coprosma robusta* and *Geniostoma.*

Apparently *Coprosma* and *Geniostoma* begin to overshadow the bracken when it is about six feet tall, as in another area *Coprosma robusta* forms a continuous canopy at about eight feet, and the bracken is then very long and spindly, with some of its fronds still reaching into the canopy. This community, which is dominated by *Coprosma,* forms the next distinct stage in the succession.

Coprosma COMMUNITY

In 1912 the steep south slope was covered in bracken about six feet high, with the tree ferns *Cyathea* and *Dicksonia* dominant in the gully. *Coprosma robusta* and *Hebe salicifolia* came through the bracken and about six years later dominated the canopy. In 1949, the tall scrub, 15 to 18 feet high, was dominated by *Coprosma* or *Melicytus.* The angle of this slope varies between 35 and 65 degrees. There is a small amount of soil and damp litter accumulated between the rocks, and small surface slips are frequent.

Near the top of the slope *Coprosma robusta* was the dominant plant, and associated with it were *Coprosma lucida, Melicytus* and *Brachyglottis repanda* (rangiora), while *Geniostoma ligustrifolium, Coprosma grandifolia* and *Suttonia australis* formed a shrub layer not always distinct from the canopy. The sparse herb layer contained young *Cyathea,* the sedge *Uncinia australis,* and two species of *Pterostylis*: *P. Banksii* and *P. trullifolia.* There were seedlings of all the species in the canopy above and also seedlings of *Beilschmiedia tawa, Knightia excelsa* and *Hedycarya arborea.* The ground was relatively bare except in places where there were small clumps of mosses and liverworts, or *Lycopodium volubile* formed a dense ground mat (Fig. 5).

Among the damp litter of dead wood and leaves, and suspended from the canopy trees were dead fronds of *Pteridium,* some of them with stipes up to 15 feet long. Apparently the bracken cannot survive in the shade when the trees form a continuous canopy above it.

As a means of estimating the ages of the trees ring counts were made by using an increment borer, and for this purpose Cockayne's statement " that for the whole of the New Zealand flora . . . it seems almost certain that the ordinary procession of events is the production of one ring of wood per year " was assumed to be correct. It was found, moreover, that where the actual dates of fires were known the ring counts coincided almost exactly with the known ages of the plants. Ring counts are therefore regarded as giving the approximate ages of the main species in the different communities.

Ring counts on this steep slope showed a characteristic form in that the rings were wider on the side away from the bank, and gave the ages of the dominants as: *Coprosma* 44 to 47, *Melicytus* 45 to 47 and *Hebe* 44 years. In the narrow belt where there was a fire in 1916 the *Coprosma* and *Melicytus* were 22 to 24 years old. In both cases *Nothopanax arboreum,* whose seedlings are usually epiphytic, was about 10 to 12 years younger than the other canopy trees.

Polypodium diversifolium was the only species other than *Lycopodium* which formed an extensive ground cover on this slope. Where more light penetrated the canopy near the top of the slope *Lycopodium* was common, while further down the slope it was replaced by *Polypodium.*

Melicytus Community

Lower on the same slope there was an almost imperceptible transition as the taller *Melicytus ramiflorus* replaced *Coprosma* as the canopy dominant in this tall shrub stage. Associated in the taller, denser canopy were *Brachyglottis* and *Nothopanax arboreum,* and just below the canopy was a tall shrub layer of *Geniostoma, Coprosma* and *Macropiper excelsum.* The commonest fern was *Blechnum lanceolatum,* and there were clumps of *Asplenium bulbiferum, Adiantum affine* and *Pellaea rotundifolia,* but only *Polypodium diversofolium* formed any extensive ground cover.

The only introduced species found on this slope were *Hypochaeris radicata* (cat's ear), *Berberis vulgaris* (barberry) and *Solanum nigrum* (nightshade), these occurred mainly along the paths. There were also a few old plants of *Ulex europaeus* (gorse) which had been smothered and were dying out.

Tawa Community

On the eastern end of the main south slope (Fig. 1) is a community dominated by *Beilschmiedia tawa,* which probably represents the climax forest association. In the canopy, together with the tawa were *Knightia excelsa* (rewarewa) and *Elaeocarpus dentatus* (hinau). Below this canopy was a dense undergrowth of several distinct layers in which lianes and epiphytes were abundant (Fig. 6). *Hedycarya arborea* and *Melicytus,* not as tall as the canopy trees, tended to form a subcanopy layer. Both these species have buttressed trunks, and their roots often extended for some distance over the surface of the ground. Forming a tall shrub layer, not always distinct from the subcanopy, were *Corynocarpus laevigata, Myrtus bullata, Brachyglottis repanda* and *Coprosma grandifolia.* Also in this layer were the lianes *Rhipogonum scandens* and *Metrosideros scandens,* and the epiphyte *Griselinia lucida.* Where more light penetrated the tawa canopy *Rhopalostylis sapida* (nikau), *Fuchsia excorticata* and the tree ferns *Cyathea dealbata* and *Dicksonia squarrosa* often formed a low subcanopy. In damper areas along the stream beds *Freycinetia Banksii* was abundant. *Macropiper excelsum* together with *Coprosma grandifolia* and *Geniostoma* dominated an extensive shrub layer at six feet. Also to be found in a few places in this layer were *Brachyglottis repanda* and old plants of *Coprosma robusta.* At two feet *Asplenium bulbiferum* dominated a layer of large ferns which included *A. lucidum, Dryopteris pennigera* and the sedge *Uncinia australis.* On the ground was a dense carpet of small creeping ferns: *Hymenophyllum demissum, Polypodium pustulatum* and juvenile *Blechnum filiforme,* there were also numerous seedlings of all the species in the layers above. The juvenile form of *Metrosideros scandens* was common on the ground before it climbed the trunks of tawa and mahoe. Also climbing the trunks from the ground layer were *Polypodium pustulatum* and *Blechnum filiforme.* Some of the older trees, in particular the hinaus, seemed weighted down with epiphytes, including *Astelia Solandri, Earina autumnalis, E. mucronata, Asplenium flaccidum, Griselinia lucida,* and seedlings of *Coprosma*

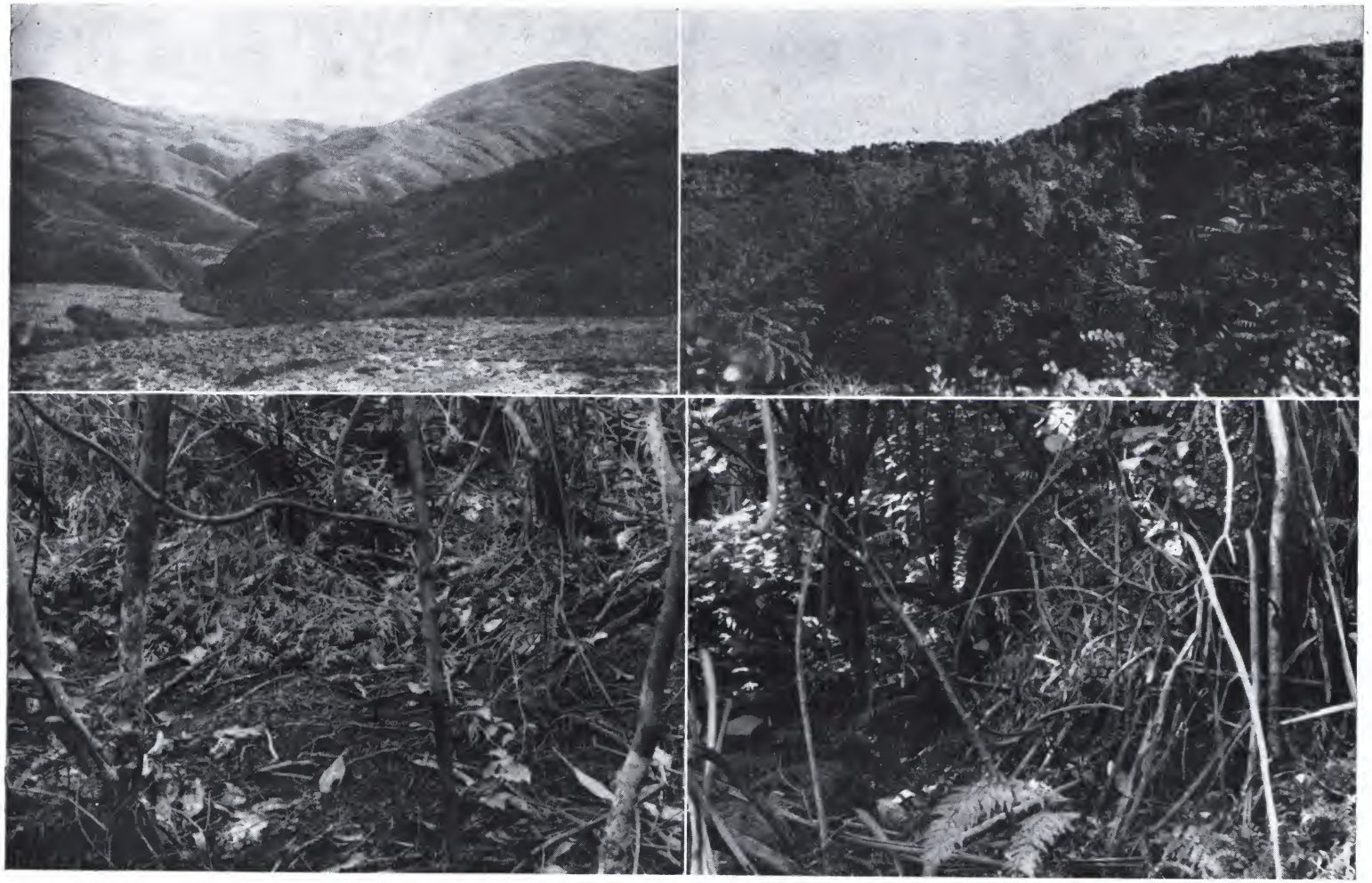

FIG. 4. Top left. General aspect of the grazing land, overgrazed flat area in the foreground with grass covered slopes in the background, the south facing slopes on the right covered in *Coprosma* scrub and tree ferns, the north facing slopes in *Cassinia*. FIG. 5. Bottom left. Ground cover under the *Coprosma robusta* canopy, *Lycopodium volubile* and litter of dead leaves and wood. FIG. 6. Bottom right. Undergrowth of the *Beilschmedia tawa* association, composed of several layers including small shrubs, lianes and large ferns. FIG. 7. Top right. Succession from bracken at the top to tree fern dominance at the bottom of the spur.

FIG. 1.—Main south slope, *Beilschmedia tawa* association with relic rimus on the right, *Coprosma* and *Melicytus* dominated shrub community on the rest of the slope.

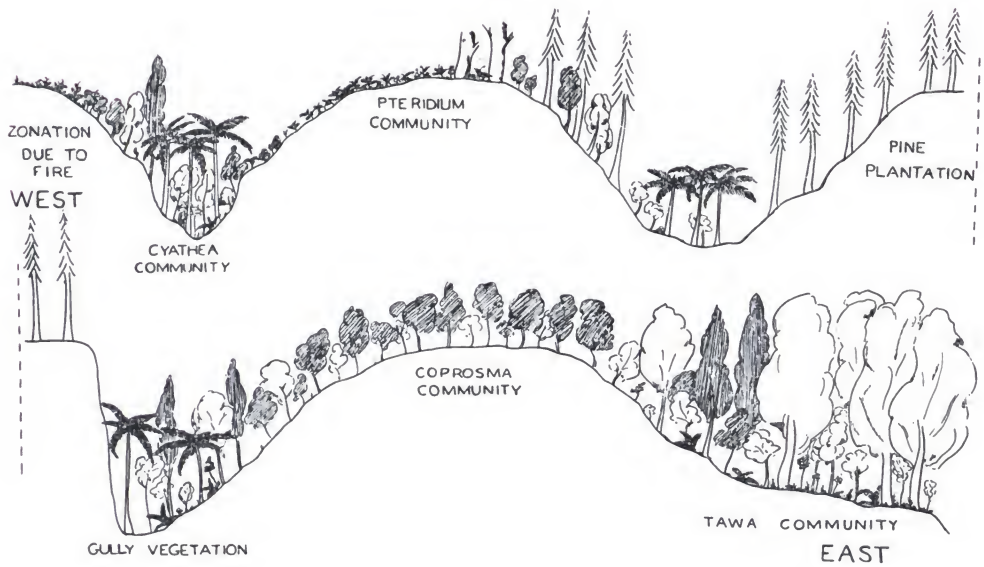

FIG. 3.—Purely diagrammatic cross section of the area from west to east. The size of the vegetation is greatly exaggerated to give an idea of the distribution of the communities and their relation to topography.

and *Nothopanax* as well as lianes Where there was more light on the margin of the association *Suttonia australis, Aristotelia serrata, Alectryon excelsum* and *Parsonsia heterophylla* were more common. Introduced species were not seen in this community.

ORIGIN OF THE TAWAS

This *Beilschmiedia tawa* association was thought to date from the original milling. Ring counts showed the dominant trees to be 76 to 78 years old and the subcanopy *Melicytus* and *Hedycarya* 72 to 76 years old. As there was no definite information on the date of milling, the following are only tentative conclusions from the available evidence. Podocarps were the dominant trees in the original forest and as tawa is often present as a subcanopy tree in podocarp communities, there are two possible ways in which the present trees could have become established; (1) after the area was milled tawa seedlings present became established as young trees; (2) the area was burnt after milling and the tawas developed later from seed. After burning and sowing the area to pasture, instead of grasses establishing, there may have been a rapid second growth of shrubs as is common on areas burnt over after milling. *Aristotelia, Melicytus* and *Coprosma* are the main species of such second growth, and tawa seedlings could have developed in their shade. This would mean that the milling would be at least ten years before the tawas established, that is probably before 1860. Ring counts, however, show that the *Melicytus* and *Coprosma* are contemporary with or younger than the tawas, and it is unlikely that in this time all trace of an earlier shrub stage should have disappeared. The most likely date of milling is about 1870, the present tawas developing from seedlings present at that time.

The tawas could be divided into three classes according to their diameters, which suggests that the area was partially cleared on two occasions after the milling. When the ring counts were made on the tawas a distinct dark ring was noticed, this was followed by one very wide ring and five or six very narrow rings, this sequence suggests that the dark rings were fire scars. Ring counts on tawa, *Melicytus, Hedycarya* and a *Coprosma robusta* (estimated to be 74 years old) all had similar scars. It is thus apparent that a fire burnt through the undergrowth 57 years previously—that is, about 1891, and this fire scorched the trees. The second group of tawas, smaller in size, and in 1949 about 56 years old, probably became established after this fire. The third group of trees may have grown up since about 1924, when the undergrowth was partially cleared and burnt.

The fire in the tawa community about 1891 may have completely burnt the vegetation on the rest of this main south slope. The tree ferns now dominant in the gully survived the fire of 1916, and may have survived earlier fires, as they do not burn readily and will continue growth after having been scorched by fire. However, the subcanopy *Melicytus* in the gully were only 46 to 47 years old: these would have established about 1901. The age of these trees, and the fact that in 1912 the rest of the slope was covered in bracken six feet tall, suggests that there was a fire later than 1891 on the slope. This apparent difference between the date of the fire (1891), and the age of the trees in the gully, which suggests a later fire, may, however, be due to a slower rate of establishment and growth of bracken and shrubs on this steep, stony slope.

Zonation Caused By Successive Fires

To the west of the area, and adjacent to the farm land, is a very interesting steep spur where a zonation of the vegetation, caused apparently by successive fires, may be observed (Fig. 7). Each successive fire originating on the farm land on the ridge above penetrated to a less extent into the gully. The last fire, which burnt only the top of the ridge, was in 1945. Here on this spur the sequence from bracken at the top to tree fern dominance at the bottom was clearly seen. At the top of the spur bracken was the dominant plant, with seedlings of *Coprosma* and *Geniostoma* under the canopy. Where the bracken was about four feet high it merged into a community dominated by large clumps of the fern *Blechnum capense.* In the shade of these clumps were found the native orchids *Orthoceras strictum, Microtis unifolia* and *Pterostylis Banksii,* and the small herbs *Ranunculus hirtus, Lobelia anceps* and *Pratia angulata.* Between the clumps of fern *Lycopodium volubile* formed a dense ground cover. None of the introduced weeds common under the bracken seemed to survive in the shade below the *Blechnum.*

Further down the slope *Coprosma* began to form a definite canopy at about six to eight feet. Apparently *Geniostoma* and *Coprosma* began to overshadow the bracken when it was about five feet high, the *Coprosma* formed a continuous canopy at eight feet, and then the bracken was very long and spindly, with its fronds still in the canopy. There were long bracken fronds suspended from the canopy with stipes up to ten feet long. Still further down the slope *Melicytus* and *Brachyglottis* dominated the canopy of an older community, the ground was covered with a litter of dead bracken and *Lycopodium,* and there were numerous seedlings of *Geniostoma* and *Weinmannia racemosa.* Still further down the slope the canopy consisted of *Cyathea* and *Dicksonia* with *Melicytus,* and the ground was comparatively bare apart from seedlings of *Melicytus* and a few tawa *Knightia.* This community gradually merged into the gully vegetation.

Gully Vegetation

In the gullies *Cyathea* and *Dicksonia* were the canopy dominants, *Hedycarya, Melicytus* and *Dysoxylum spectabile* were the subcanopy trees, and there was a dense tangle of *Rhipogonum scandens, Freycinetia Banksii, Lycopodium Billardieri* and *Metrosideros scandens* suspended from the sub-canopy. At six to eight feet there was a shrub layer of *Macropiper, Brachyglottis,* young tawa and *Schofflera digitata.* In the dense fern layer were *Asplenium bulbiferum, Dryopteris pennigera* and *Blechnum lanceolatum.*

This was typical of the gully vegetation in this area, where the ground is always damp and covered with mosses, liverworts and small ferns, and a litter of dead leaves and twigs. This community can be regarded as a stage intermediate between the shrub community dominated by *Melicytus* and the forest dominated by *Beilschmiedia.* The tawa saplings present in the gully vegetation will probably finally dominate the community forming a tawa association similar to that described.

Discussion

That there is a sequence of communities on the one slope showing all the stages described from the separate areas suggests that this is the actual course of regeneration on damp south facing slopes. This is further emphasised by

the fact that the seedlings under the bracken canopy are those of the dominants of the shrub stage, and that the tawas first appeared as seedlings in the *Coprosma* scrub. In the gullies under the tree ferns and *Melicytus* the tawas were well developed as saplings, while finally tawa was the dominant tree in the forest.

Coprosma and *Geniostoma* are the first native shrub species to become established under the bracken canopy, and about eight feet the *Coprosma* forms a continuous canopy above the bracken. *Coprosma* then dominates the canopy of a community that can be regarded as the first shrub stage. Gradually *Melicytus* replaces *Coprosma* as the canopy dominant and dominates another distinct shrub community. This has a taller, denser canopy and a more varied undergrowth, with several new species. At this stage tawa, *Knightia* and *Hedycarya* seedlings are well established in the undergrowth In the damp gullies where fire does not readily penetrate, is a typical community which often seems to merge with that dominated by *Melicytus*. This is the community in which the canopy is dominated by tree ferns. *Melicytus* and *Dysoxylum* form a tall subcanopy under the *Cyathea* and *Dicksonia,* and *Macropiper* forms a distinct shrub layer in which tawa saplings are prominent. There are large clumps of ferns, while small ferns, mosses and liverworts form an extensive ground cover. It is probable that this community is another definite seral stage, distinct from that dominated by *Melicytus*. *Knightia excelsa* seems to be the first of the forest trees to appear above the tree fern canopy, and the tawa would probably, from this stage, gradually decome dominant, forming a definite forest community. In the present tawa forest associated in the canopy are *Knightia* and *Elaeocarpus*. Lianes and epiphytes become abundant and there is a layered undergrowth composed of many species.

The shrub communities dominated by *Coprosma, Melicytus* and *Cyathea* are definite stages in this succession and are seral communities not stable associations, although there may be little apparent change over a period of 20 to 30 years. These seral communities could be called associates if the tawa community is regarded as climax forest and a relatively stable association. They differ from the climax forest in having a lower canopy often composed of many species and a much sparser undergrowth.

Cockayne says of tawa dominated forest " that it may be considered the final stage in the series of succession forming taxad forest, that is to say, that wherever it occurs one may conclude that forest rich in taxad previously occupied the ground." In this area the original podocarp forest was milled and the tawa forest has directly replaced it. Cockayne seems to consider that the tawa will naturally replace the podocarp which thus could only be a subclimax forest and the tawa forest the true climax association. If, however, as seems possible from present-day vegetation near Wellington, the replacement by tawa is mainly in areas where there has been some disturbance of the podocarp forest, then the tawa may be a deflected climax association. Another possibility is that in many years' time the uneven canopy of the tawa forest may become sufficiently open to allow growth of podocarp species. Podocarp seedlings require more open conditions for growth than tawa and do not seem to be able to establish when overshadowed by competing broadleaf species, so that it seems unlikely once tawa has established as the dominant tree that the podocarps will regenerate and again dominate the association. There are two fine specimens of *Dacrydium cupressinum* (rimu) in the tawa association. These are relics of the podocarp forest and

they stand out well above the other trees (Fig. 1). The only other podocarps present were three young saplings which were almost choked out by the other vegetation.

This tawa association was compared with three other similar associations all containing relic podocarps. Although there were a few seedling podocarps these did not seem to be able to survive past the sapling stage, and there were no signs of incipient regeneration of podocarp forest.

Where the podocarp forest has been milled, and in many cases burnt, and the land sown with grasses it seems that in some places the establishment of

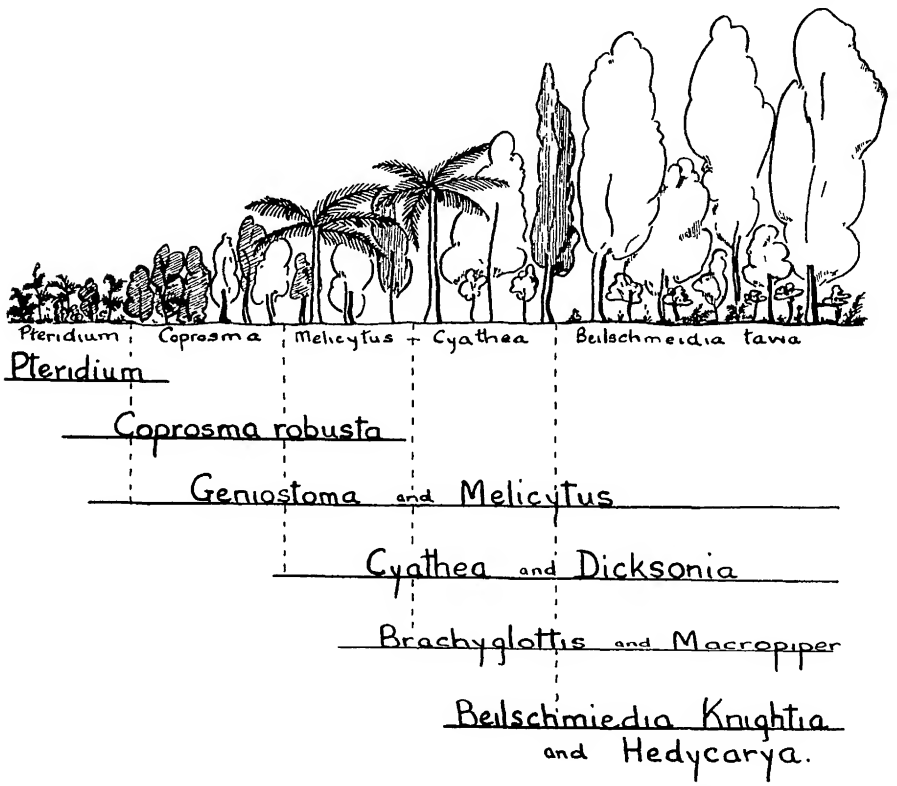

FIG. 8.—Diagrammatic representation of the positions of the most important plants in the succession bracken to tawa forest.

permanent pasture has been unsuccessful. Then, as on these Western Hutt hills, regeneration of forest will take place through stages of bracken and mixed scrub to climax forest dominated by *Beilschmiedia tawa* (Fig. 8). In this area it would take about 80 years for the tawa to become the dominant tree.

A summary of the course of regeneration and the estimated time is given in the form of a table (Fig. 9).

ACKNOWLEDGMENTS

I wish to express my very sincere thanks to Dr. H. E. Gibbs, sen., for permission to study the vegetation on his property at Belmont, and I am grateful for his interest in this work. Also I acknowledge my indebtedness to Professor

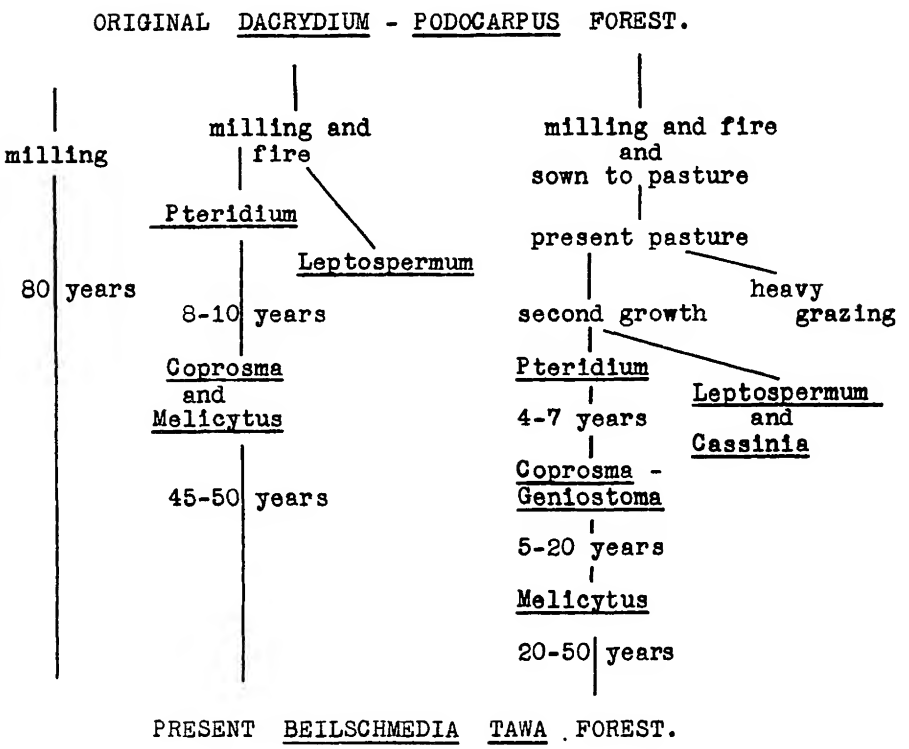

FIG. 9.—Summary of the probable relationships of the various plant communities to each other and to the course of regeneration.

H. D. Gordon and Dr. J. G. Gibbs, of the Botany Department, Victoria University College, for their encouragement and helpful suggestions both during the original work and in the preparation of this paper. I also thank Mr. J. S. Reid, of New Zealand Forest Service for the loan of his increment borer and reference to his unpublished thesis on the vegetation of Wilton's Bush.

REFERENCES

COCKAYNE, L., 1927. *Vegetation der Erde*: Vegetation of New Zealand.

COTTON, C. A., 1949. *Geomorphology*. (Revised 5th edition.)

CROKER, B. H., 1949. Some Observations on Regeneration of Lowland Forest. (Unpublished thesis, Victoria University College library.)

LEVY, E. B., 1923. Grasslands of New Zealand. Principles of Pasture Establishment. *Dept. Agric. Bull.* 107, Chap. 5.

LOWER HUTT BOROUGH COUNCIL. *Lower Hutt Past and Present.*